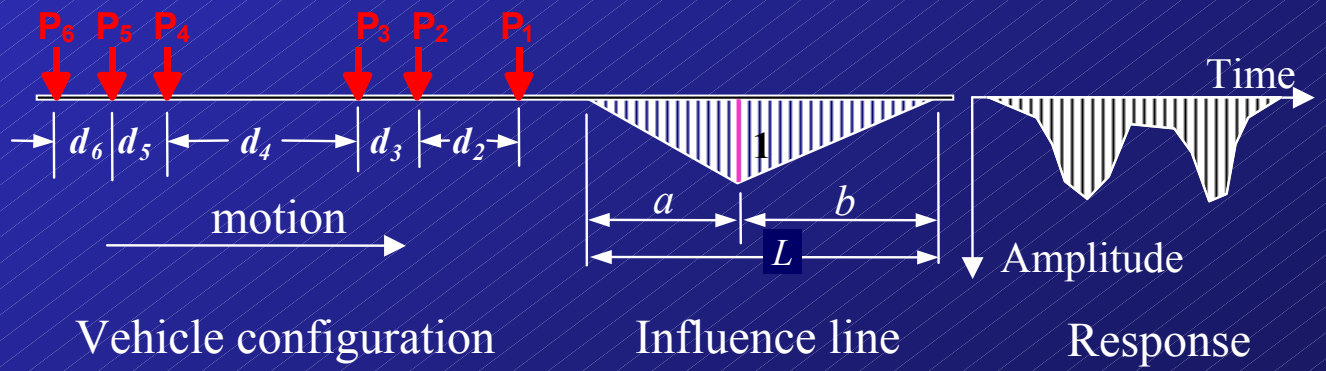
Accommodation of Time Dependent Drift in Weigh-in-Motion Data

Paul Grundy[1] *Joe Grundy*[2]
Hussein Khalaf[1] *Raoul Casagrande*[3]

[1]*Department of Civil Engineering, Monash University, Melbourne*
[2]*Quadcore Pty Ltd, Melbourne, Australia*
[3]*Information Services, VicROADS, Melbourne, Australia*

Background

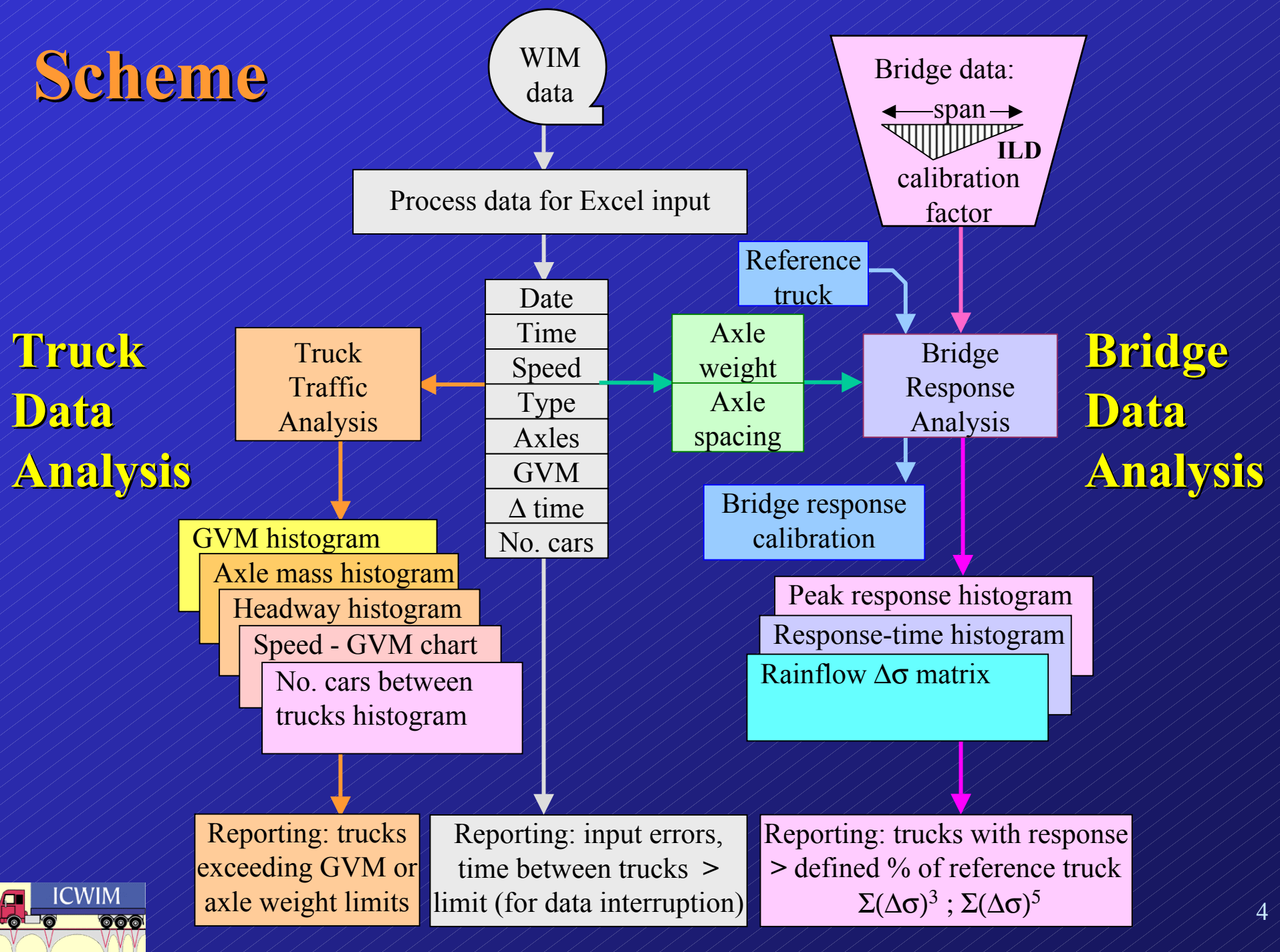
- A collaborative research program between VicRoads and the Department of Civil Engineering at Monash University is in progress on the safety and reliability of ageing bridges.
- Records of truck traffic from Culway data are used to construct a procession of axle weights with given spacing which are passed over the influence line of existing bridges.



Background

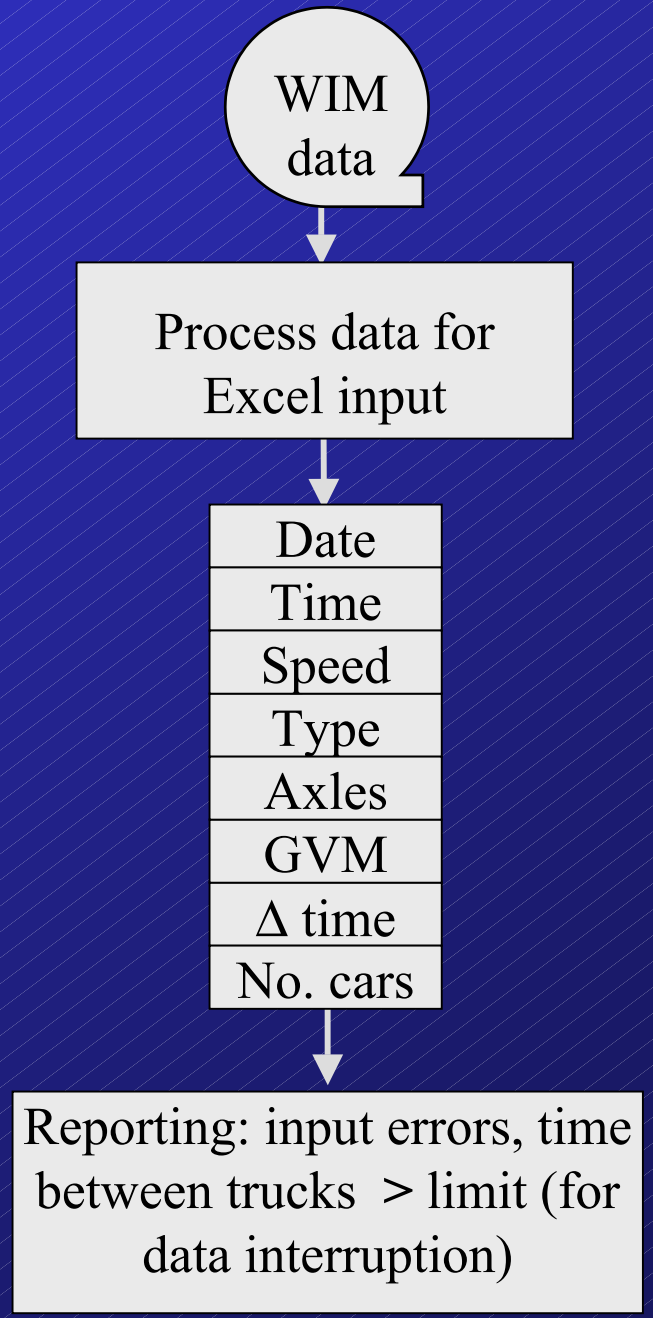
- A spectrum of bridge response is obtained and used in probabilistic modeling of extreme events and/or the historical fatigue loading.
- Bridge strength is estimated using numerical modeling based upon current inspection and measurement of dimensions and properties.
- A nominal risk of failure is obtained which enables the bridge asset manager to prioritize replacement, strengthening and repair.

Scheme


WIM data
Process data for Excel input
Bridge data:
span
ILD
calibration factor
Reference truck
Date
Time
Speed
Type
Axles
GVM
Δ time
No. cars
Truck Traffic Analysis
Axle weight
Axle spacing
Bridge Response Analysis
Truck Data Analysis
Bridge Data Analysis
GVM histogram
Axle mass histogram
Headway histogram
Speed - GVM chart
No. cars between trucks histogram
Bridge response calibration
Peak response histogram
Response-time histogram
Rainflow Δσ matrix
Reporting: trucks exceeding GVM or axle weight limits
Reporting: input errors, time between trucks > limit (for data interruption)
Reporting: trucks with response > defined % of reference truck
Σ(Δσ)³ ; Σ(Δσ)⁵

Objectives

- Maximise accuracy of truck data
- Correct for drift



A Culway site


Culvert
instrumentation

Observations on Field Data

- WIM sites calibrated with a rigid truck and an articulated A123 truck
- Calibrations two or more years apart
- Sometimes significant drift between calibrations
- Average GVM and group axle mass drifted over months (Lim 1992)
- Diurnal variations noted (Lim 1992)

Observation

- Average gross Vehicle Mass (GVM) changes little and slowly with time
- Average Steering Axle Mass (SAM) changes even less
- Average SAM of articulated trucks changes least of all (no direct freight on SAM)

Hypothesis

Use the constancy of average SAM to correct for seasonal and diurnal drift in WIM sensitivity.
(Peters, 1997)

Methodology

For a given WIM site and data acquisition period:-

- Select a common class of articulated truck
- Remove highest and lowest extreme values of axle mass and axle spacing
- Obtain multiple correlations between SAM and
  - Drive axle mass
  - Steering to leading drive axle spacing
  - Drive axle spacing
  - Day (week) of the year
  - Hour of the day
- Correlate with calibration or known average SAM to obtain correction factor by day and hour

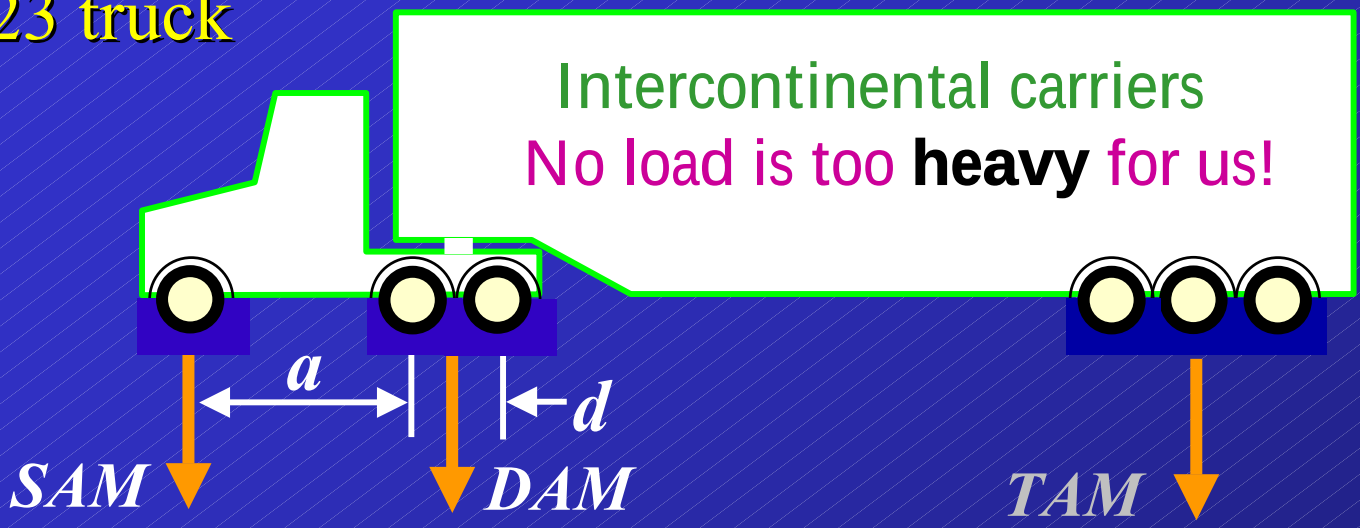
Do **NOT** attempt correlation with meteorological data!

Keep the system internally consistent and independent of the site and the gathering of external data.

Application

- BRAWIM® (Bridge Response Analysis from Weigh-In-Motion data) developed to analyze Culway data
- A123 truck selected
- Culway sites in Victoria with AADT in slow lane ranging from 100 to 2,500
- Sample period 6 months

A-123 truck

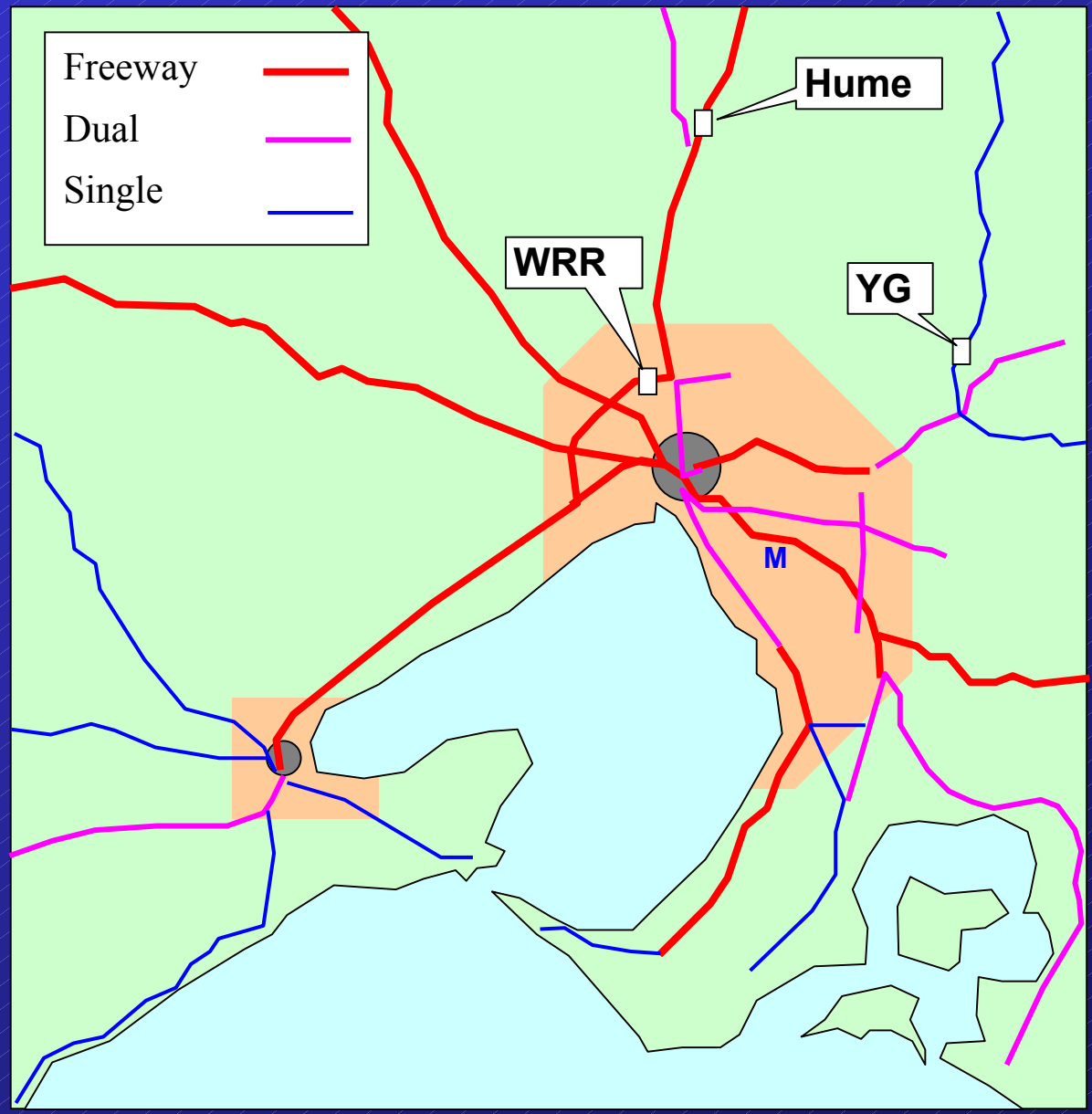


Parameters are *SAM, DAM, a, d.*

The fleet is mixed

Culway Sites

Western Ring Rd
(2400 AADT
slow lane)
and
Yarra Glen
(120 AADT west
bound)
used for this study

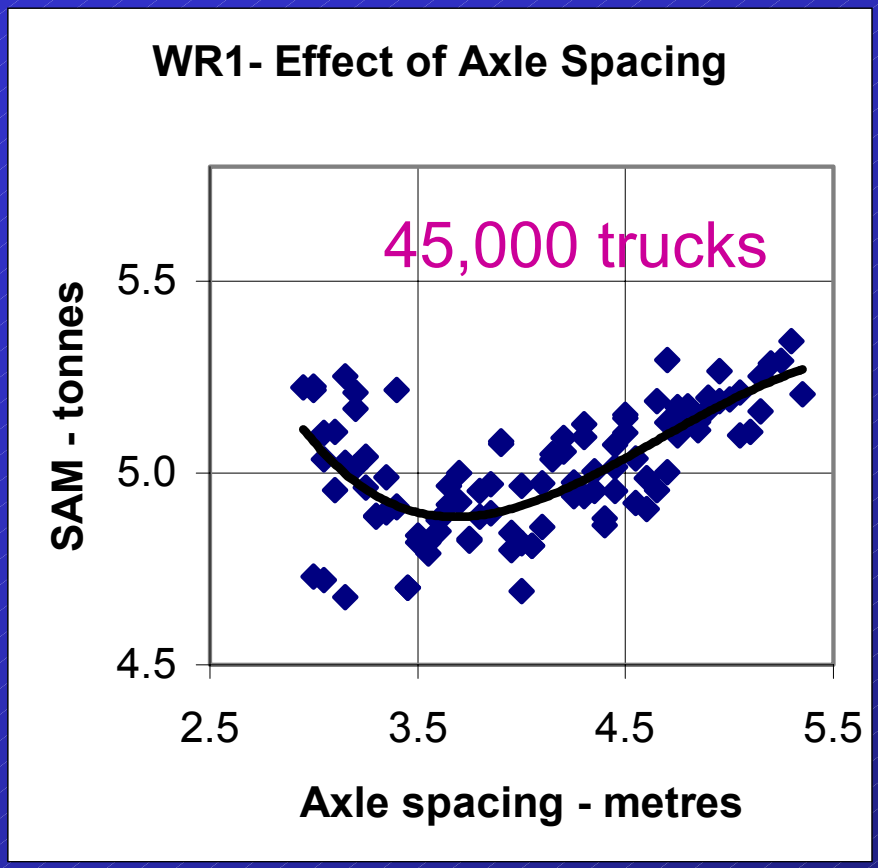


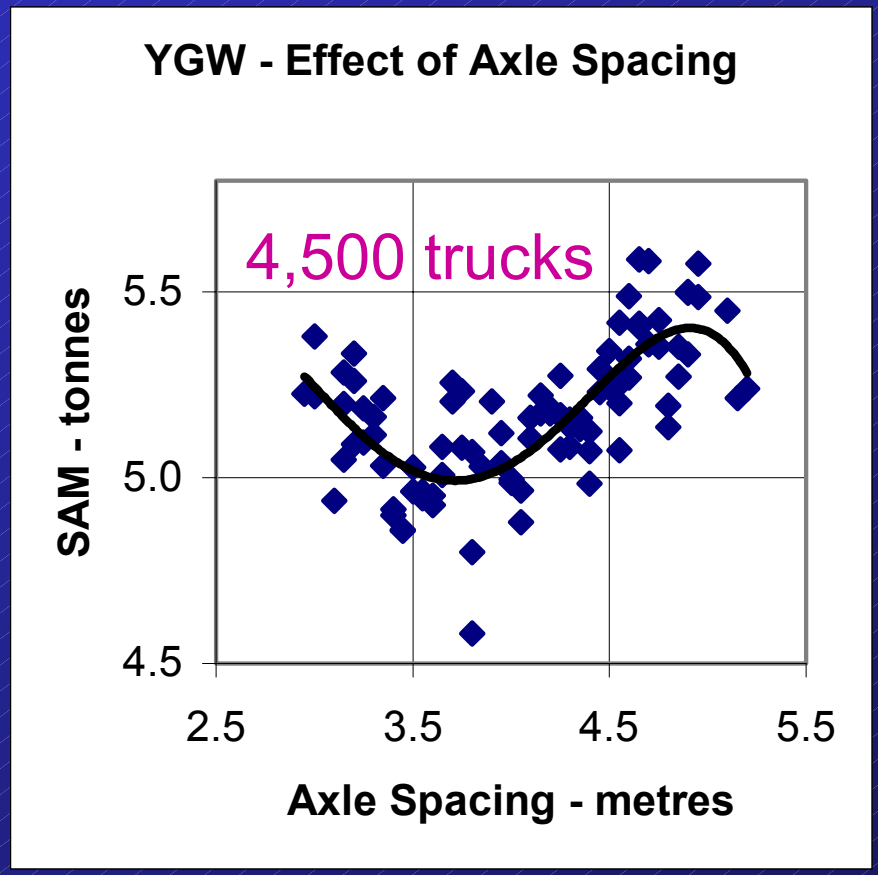
Melbourne – "Most liveable city"

Methodology

- Obtain multiple correlations between SAM and
  - Drive axle mass
  - Steering to leading drive axle spacing
  - Drive axle spacing
  - Day (week) of the year
  - Hour of the day
- Correlate with calibration or known average SAM to obtain correction factor by day and hour
- Iterative least squares error fit to data
- No *a priori* function used – hypothesis free

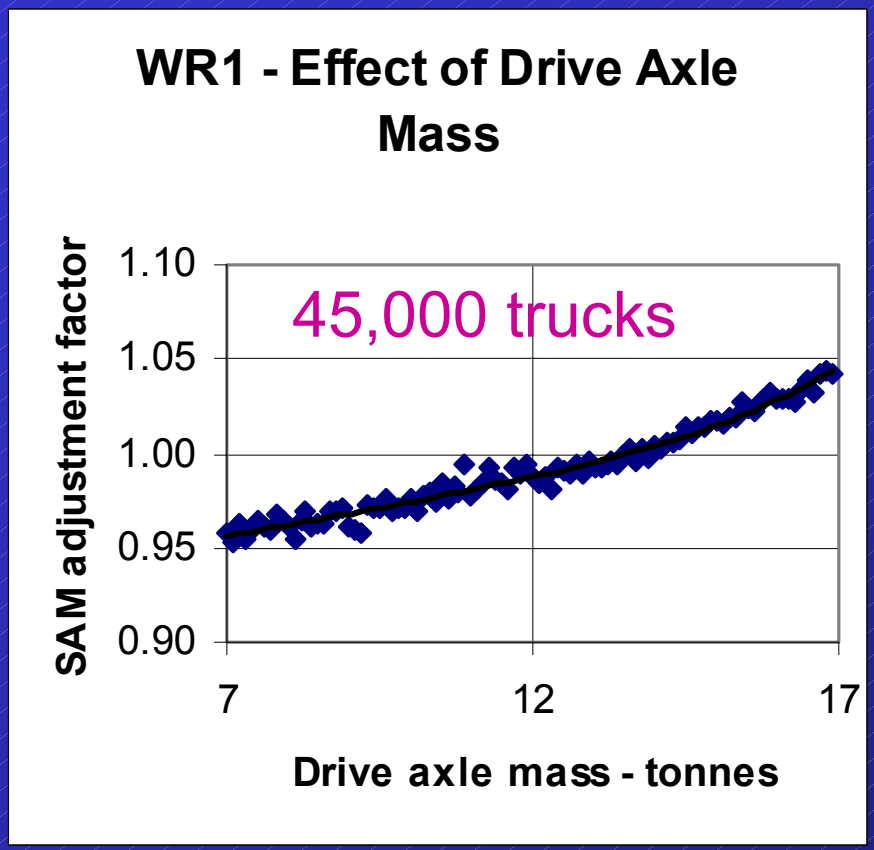
SAM versus Axle Spacing "*a*"

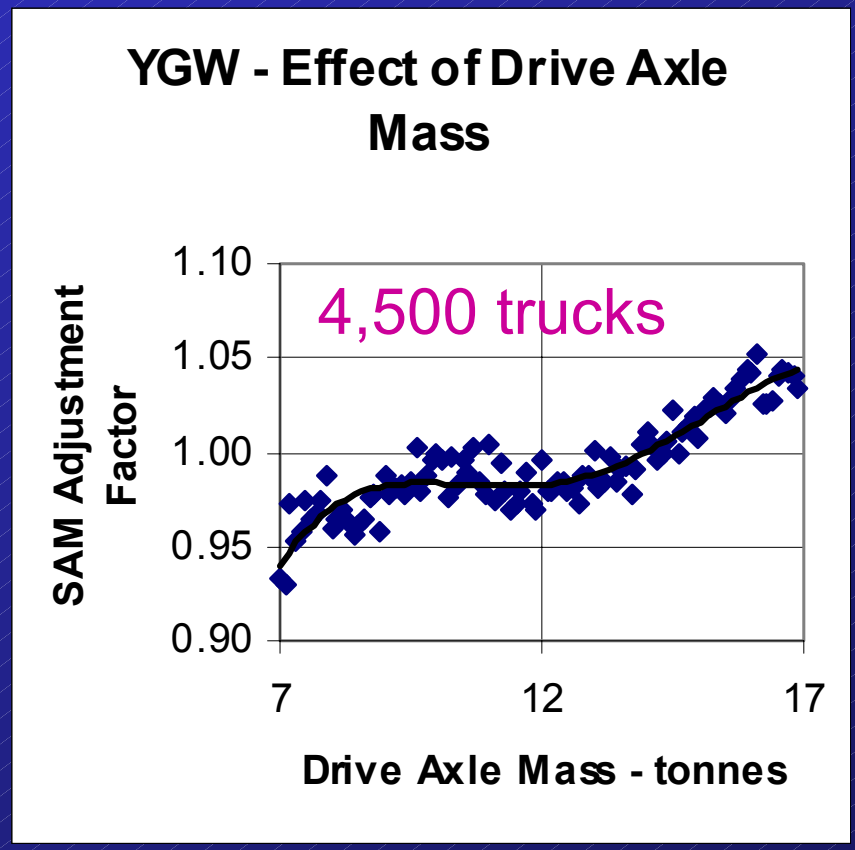




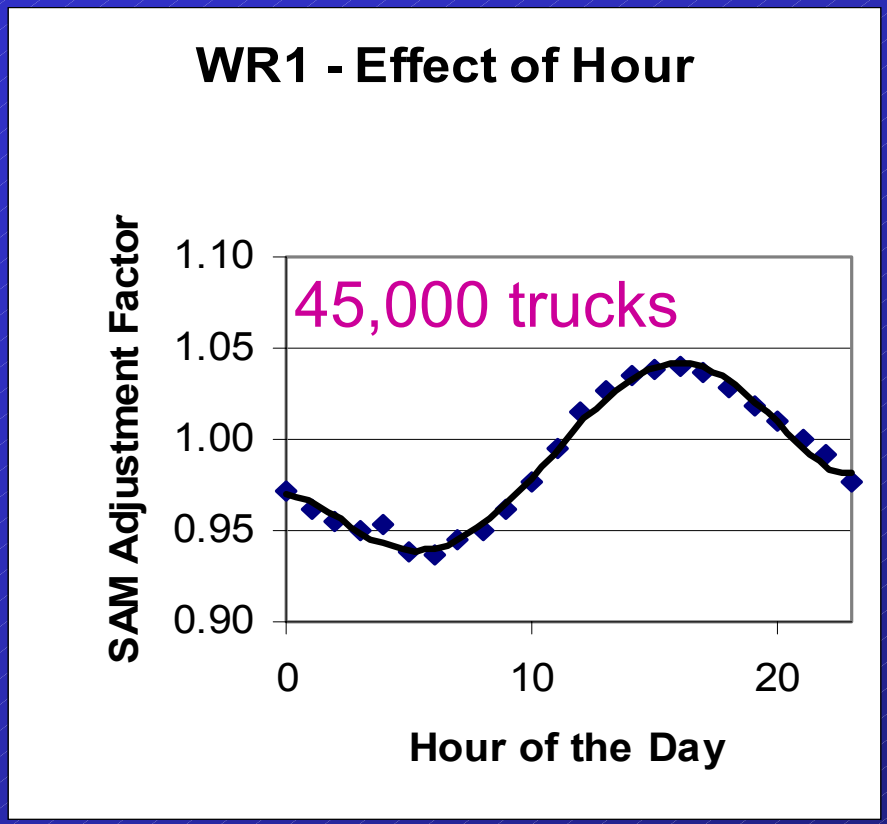
ICWIM

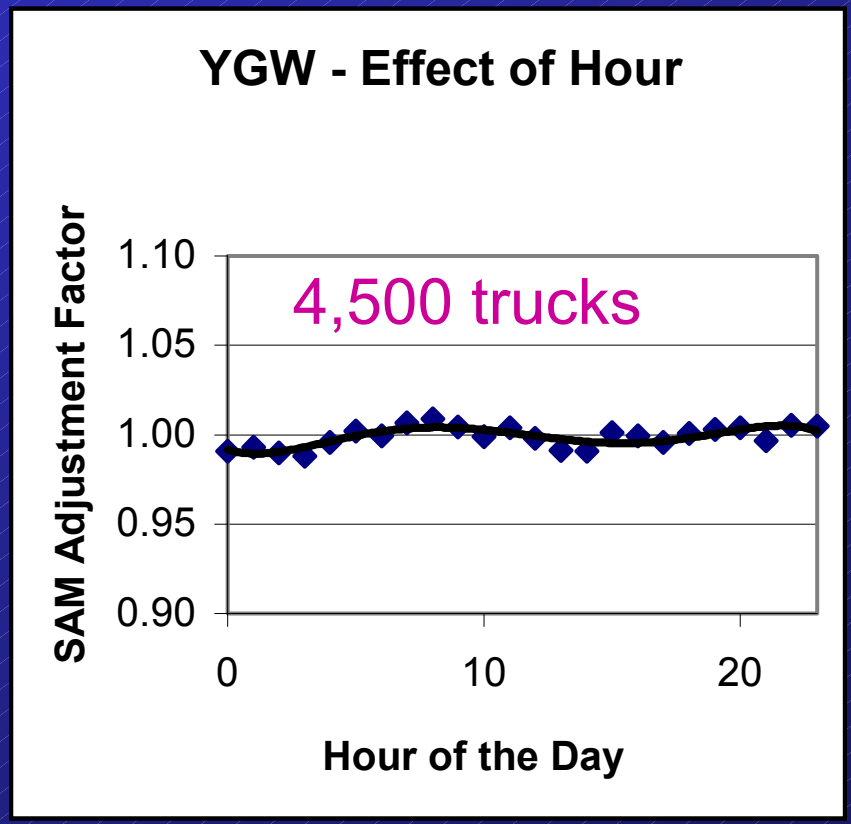
SAM versus Drive Axle Mass





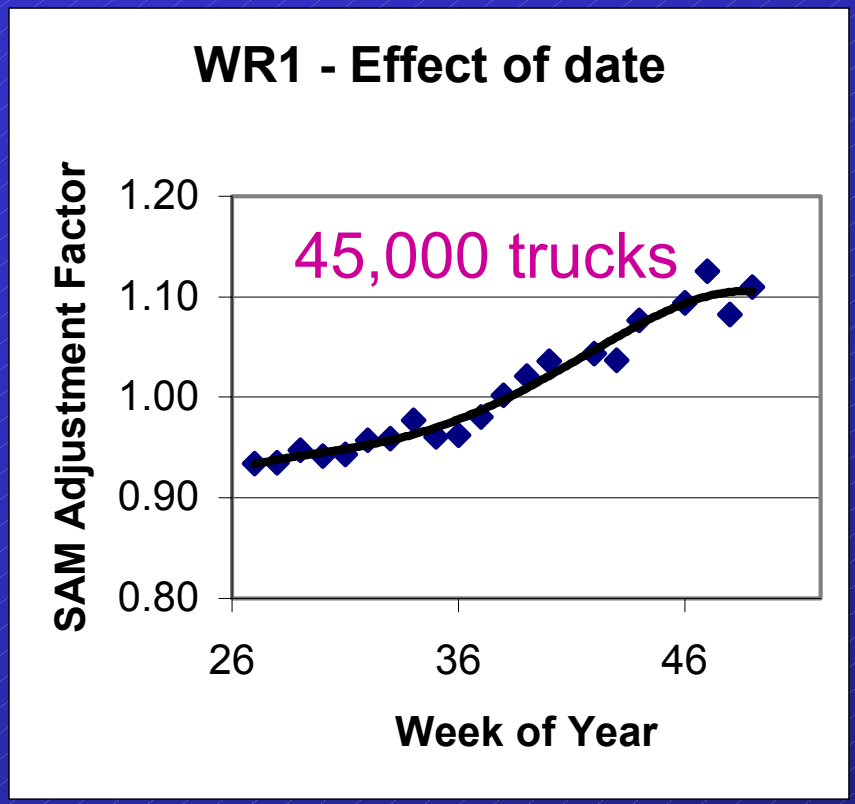
SAM versus Hour of the Day

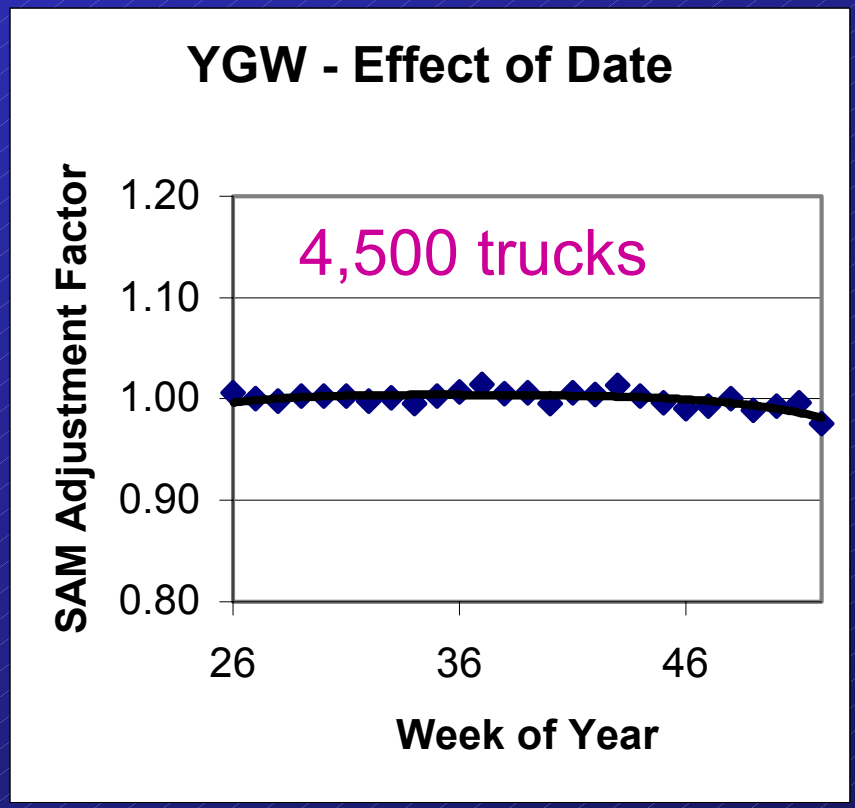




ICWIM

SAM versus Week of the Year





ICWIM

Remarks

1. Average SAM is related to different calibration events at the two sites. Approximately 0.15 tonnes (3%) higher at Yarra Glen.
2. WWR site, with high diurnal variation in SAM, has porous surface allowing air and water to drain through. YG site, with low diurnal variation, has a traditional seal.

Remarks

3 Trend lines are fitted to time dependent apparent variations in SAM, but not to truck configuration data.

4 Weekly averages used in applying correction factors to data could be replaced by daily averages, but data becomes sparse.

Conclusions

1. A method of adjusting WIM data to correct for seasonal and diurnal drift, based upon constancy of the Steering Axle Mass for a specific class of truck, has been developed.
2. The true average of the SAM for the reference group of trucks needs to be obtained by cross referencing physical calibrations.
3. Trends in SAM due to changing configuration of the reference group of trucks need to be monitored.

Acknowledgements

For financial support and technical input

VicRoads

Australian Research Council (APAI award)

Thank you for your attention.